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ELECTROOPTICAL DISPLAY DEVICE
[Denkikogakuteki Hyoji Sochi]

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(54) Title of the Invention: ELECTROOPTICAL DISPLAY DEVICE

(57) Summary

An electrooptical display device with the following characteristics: In an electrooptical display device which possesses a switching device constituted by a silicon thin film transistor, etc. as well as by a drive electrode, the functional element of said [sic: No referent] peripheral drive circuit is constituted by a silicon thin film transistor, and a peripheral drive circuit which feeds signals into data lines and gate lines is configured on said [sic] glass substrate on the outer circumference of an active matrix circuit unit while only the data line peripheral drive circuit section of the peripheral drive circuit has been laser-annealed.

Claim

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An electrooptical display device with the following characteristics: In an electrooptical display device which has been obtained by enclosing a composition which exhibits an electrooptical response between a pair of glass substrates and wherein an active matrix circuit unit is configured on said glass substrate by configuring data lines and gate lines matrixwise and

¹Numbers in the margin indicate pagination in the foreign text.

by configuring a switching element constituted by a silicon thin film transistor and a drive electrode at each intersection of said data lines and gate lines, the functional element of said [sic] peripheral drive circuit is constituted by a silicon thin film transistor, and a peripheral drive circuit which feeds signals into data lines and gate lines is configured on said glass substrate on the outer circumference of an active matrix circuit unit while only the data line peripheral drive circuit section of the peripheral drive circuit has been laser-annealed.

Detailed explanation of the invention

[0001]

(Industrial application fields of the invention)

The present invention concerns an active matrix substrate which is obtained by configuring at least a main constituent unit of polycrystalline silicon or amorphous silicon above a transparent substrate (e.g., sodium glass, borosilicate glass, quartz, etc.).

[0002]

(Prior art of the invention)

In recent years, the application fields of flat panel-type liquid crystal displays have been expanded not only to wrist watches, electronic calculators, and toys but also to automobiles, measurement instruments, information machine peripherals, etc. Very recently, in particular, an liquid crystal display panel for a television image display obtained by

forming a stretching [sic: Presumably "switching"] transistor circuit above an Si substrate based on a semiconductor integrated circuit technique and by enclosing a liquid crystal between said Si substrate and a transparent glass sheet has been developed.

[0003]

As far as embodiments in which liquid crystal panels are constituted based on the active matrix format are concerned, one which uses the aforementioned monocrystalline Si substrate, one wherein a thin film transistor is formed above a glass substrate, one which uses a varistor substrate, etc. have already been proposed. Of these, the aforementioned active matrix substrate obtained by forming a thin film transistor above a glass substrate is regarded as promising in the future in consideration of the cost performance and the possibility of providing a large-sized panel.

[0004]

It has heretofore been well-known that a low-temperature process must be used for a thin film transistor obtained by depositing polycrystalline silicon, etc. on a glass substrate due to thermal limitations on the substrate. In the case of the aforementioned active matrix which uses a thin film transistor, however, high-frequency actions are required for the peripheral drive circuit, although they may not be mandatory for the active matrix circuit, and therefore, the mobility must be comparable to that of monocrystalline silicon. For this reason, therefore, the peripheral drive circuit is commonly formed above a

monocrystalline silicon substrate and then externally attached to an active matrix substrate.

[0005]

(Problems to be solved by the invention)

In the aforementioned conventional method, however, significant cost increases are obviously inevitable in consideration of the peripheral drive circuit substrate production cost as well as the active matrix substrate external attachment cost. In a case where an active matrix substrate is formed by using a heat-resistant substrate material (e.g., quartz substrate, etc.), on the other hand, a high-temperature process of 1,000°C or higher is applicable, and therefore, it is possible to manufacture an active matrix substrate in which a peripheral drive circuit has been internalized.

[0006]

One problem of such an alternative is an optical leak. Flat panel-type liquid crystal displays have high utility values as portable and outdoor appliances, and accordingly, they are obviously used in high frequencies in the presence of sunlight.

[0007]

Since the display plane of an active matrix IC substrate is irradiated directly with the sunlight, incident beams arrive at the interior of the IC substrate. Electrons and positive holes are generated by such incident beams arrive at the interior of the IC substrate, and when they arrive at a P-N junction as a result of diffusion within the substrate, a current is permeated

through said P-N junction. In other words, the foregoing photoelectromotive effects entail a leak in the source-drain P-N junction of the transistor, as a result of which it may become impossible to obtain a correct image display, or the displayed image may flicker or fade. One known mechanism for mitigating the aforementioned optical leak phenomenon is to reduce the leak current by minimizing the mobility of the substrate, and it is applicable to the aforementioned active matrix circuit to a certain extent.

[0008]

The entire polycrystalline silicon above the quartz substrate, however, is crystallized as a result of the aforementioned high-temperature process, as a result of which the mobility inevitably increases, accompanied by an optical leak gain. Thus, it cannot be said to be a desirable mechanism.

[0009]

In recent years, furthermore, techniques for crystallizing amorphous or polycrystalline silicon images [sic] or for eradicating damages incurred during ion implantation by irradiating laser beams or EB (electron beams) on them have been developed, as has been well-documented.

[0010]

In particular, various formats are conceivable for laser heating (e.g., CW argon laser, CW krypton laser, pulse YAG laser, CW excitation-type YAG laser, etc.). There are substantial structural and action-specific differences [among them] with

regard to not only the output, energy, and the spot diameter but also the productivity and stability, and therefore, an objective-specific selection becomes an important factor.

[0011]

If a laser annealing technique which involves said laser beams is implemented, an active matrix substrate which has been obtained by internalizing a peripheral drive circuit in a glass substrate can be laser-annealed, and as a result, the overall mobility can be enhanced. As far as such laser-annealing effects are concerned, however, the throughput is determined by the spot diameter and the irradiation period, and in a case where an entire substrate is laser-annealed, therefore, the productivity is low (e.g., several substrates per hour). Thus, the efficiency of the foregoing scheme is extremely inferior.

[0012]

In order to manufacture a low-cost active matrix substrate which is resistant to optical leaks, therefore, it is necessary to alleviate the aforementioned various shortcomings of the prior art.

[0013]

(Mechanism for solving the problems)

/3

The shortcomings of the prior art are eradicated by the present invention. In other words, an active matrix circuit which includes polycrystalline silicon or amorphous silicon as a main constituent component is formed above a transparent substrate (e.g., glass, etc.), and a peripheral drive circuit is

configured above the same substrate in such a way that said active matrix circuit will be wrapped; the mobility of the transistor is improved by laser-annealing the region of said peripheral drive circuit alone. In other words, an annealing laser is irradiated on the drive circuit of the substrate peripheral unit alone as a mechanism for internalizing a peripheral drive circuit and for elevating the mobility, as has been mentioned above, and since the mobility of the internalized active matrix circuit is also minimized, improved effects of preventing optical leaks can be achieved.

[0014]

(Application examples)

Next, the present invention will be explained in detail with reference to application examples shown below.

[0015]

Application Example 1

Figure 1 shows an active matrix substrate of the present invention. The active matrix circuit (2) is configured above the borosilicate glass substrate (1) at its center, whereas the peripheral drive circuit (3) is configured on it around its outer circumference.

[0016]

Figures 2 (a) through (c) are diagrams which show cross-sectional views of the substrate and which are provided for explaining the production processes for the active matrix substrate of the present invention. First, as Figure 2 (a)

indicates, the first polycrystalline silicon film (4), the thickness of which is 5,000 Å, is formed above the borosilicate glass substrate (1) at 625°C in a reduced-pressure atmosphere, and subsequently, said first polycrystalline silicon film (4) is partially photoetched for forming a hole. Next, the fringe above the substrate (i.e., inside the region of the peripheral drive circuit (3) shown in Figure 1) alone is laser-annealed in the order of 1 through 4 while laser beams (beam diameter: 200 μm; linear velocity: 50 cm/sec.), which have been derived from a CW excitation-type YAG laser light source, are being scanned between left and right. Next, the CVD-SiO₂ film (5) is deposited at a thickness of 2,000 Å, as Figure 2 (b) indicates, and after the second polycrystalline silicon film (6) has subsequently been formed according to procedures identical to those for forming the aforementioned first polycrystalline silicon film, a hole is formed in the source-drain section of the second polycrystalline silicon film (6) by means of photoetching.

[0017]

Next, phosphorus ions are irradiated on the substrate primary plane at $1 \times 10^{15}/\text{cm}^2$, and after it has been annealed in a forming gas at 550°C for 1 hour, a diffusion layer is formed. Next, the CVD SiO₂ film (7) is formed, as Figure 2 (c) indicates, and after a contact hole has subsequently been formed on it, the electrode (8) is formed, as a result of which the formation of the active matrix substrate is completed. The numbers of the gate and data lines of the active matrix circuit employed in the

present application example are 200 each. In a case where the present substrate was employed, data line and gate line actions at approximately 1 KMHz and 25 KMHz were confirmed, respectively, and thus, sufficient performances as a liquid crystal display device were verified. As far as the laser-annealing effects are concerned, the annealing throughput was several times higher than the conventional figure, whereas the mobilities of the active matrix circuit and peripheral drive circuit were approximately 10 cm/V-sec. and approximately 100 cm/V-sec., respectively.

[0018]

Application Example 2

After the polycrystalline silicon film shown in Figure 1 had been formed according to procedures identical to those in Application Example 1, it was partially photoetched (2) [sic] for forming a hole, and subsequently, the regions of the peripheral drive circuits (1) and (3) were laser-annealed under conditions identical to those in Application Example 1, as Figure 3 (b) indicates. Subsequently, the regions of the peripheral drive circuits (2) and (4) were irradiated at an energy density output lower than that for (1) and (3) (i.e., approximately 1 J/cm²). The peripheral drive circuit regions of (2) and (4) are configured for driving the gate lines. Since low-frequency actions are possible in comparison with the data lines of (1) and (2), there is no need to irradiate the entire peripheral drive circuit unit at an invariable energy density. The results obtained in the present application example also confirmed that a

sufficient mobility for invoking gate line actions can be achieved. Since two sides of the substrate outer circumference are irradiated at a low energy density, furthermore, the throughput is further improved as compared with Application Example 1.

[0019]

Application Example 3

After a first polycrystalline silicon film had been formed according to procedures identical to those in Application Example 1, it was partially photoetched for forming a hole, and subsequently, the peripheral drive circuit regions (1) and (3) (i.e., data line drive circuit regions) alone were laser-annealed, as Figure 3 (c) indicates. In other words, the present format is sufficiently effective for an active matrix substrate with an especially small number of gate lines, as has been explained in Application Example 2, and a significantly improved throughput can be expected.

[0020]

Application Example 4

After a first polycrystalline silicon film had been formed according to procedures identical to those in Application Example 1, it was partially photoetched for forming a hole, the peripheral drive circuit region (1) was first laser-annealed by scanning the irradiated laser beams between left and right, as the arrow in Figure 3 (d) indicates, and after the substrate had subsequently been rotated by 90° around its center, the region

(2) was irradiated according to procedures identical to those for (1), and after the substrate had been likewise rotated, the regions (3) and (4) were irradiated. In this format, the beam scanning frequency can be significantly lowered as compared with Application Example 1, which is advantageous since the throughput can be improved as compared with Application Example 1.

[0021]

As the foregoing explanations of Application Examples 1 through 4 indicate, a single chip which includes an active matrix circuit and a peripheral drive circuit is configured above a substrate in the active matrix substrate of the present invention, which is used for panel-type liquid crystal displays, etc., and at the same time, the drive circuit alone is irradiated with an annealing laser beam based on the application of the laser annealing technology in order to confer optical leak resistance on the active matrix substrate. Thus, an active matrix substrate which is resistant to optical leaks can be provided at a low cost.

[0022]

Although borosilicate glass substrates were employed as transparent substrates in the foregoing application examples, other transparent substrates such as sodium glass, quartz sheet, etc. can also be employed. Not only the annealing lasers but also EB, etc. have been proven to be effective for elevating the transistor mobility, and the conditions for irradiating them can be freely selected in consideration of application objectives.

It is obvious that these adjustments in no way deviate from the scope of the present invention.

[0023]

(Effects of the invention)

/4

As has been mentioned above, the present invention provides the following constitution: In an electrooptical display device which has been obtained by enclosing a composition which exhibits an electrooptical response between a pair of glass substrates and wherein an active matrix circuit unit is configured on said glass substrate by configuring data lines and gate lines matrixwise and by configuring a switching element constituted by a silicon thin film transistor and a drive electrode at each intersection of said data lines and gate lines, a peripheral drive circuit which feeds signals into data lines and gate lines is configured on said glass substrate on the outer circumference of said active matrix circuit unit, and the functional element of said peripheral drive circuit is constituted by a silicon thin film transistor in such a way that the mobility of the silicon thin film transistor of said peripheral drive circuit will differ from the mobility of the silicon thin film transistor in said active matrix circuit. In such a case, regions with different mobilities can be easily formed by varying the compositions of silicon thin film transistors by means of a laser-annealing treatment, etc., and if the mobility is elevated, high-frequency responses of the peripheral drive circuit can be guaranteed, and since the mobility of the active matrix circuit is mitigated, the

leak current in a transistor OFF state, which is attributed to incident beams which arrive at the display region, can be minimized. Thus, a pair of thin film transistors with mutually contradictory mobilities can be constituted above a singular substrate.

Brief explanation of the figures

Figure 1: Circuit configuration diagram pertaining to the active matrix substrate of the present invention.

Figures 2: (a) through (c) are diagrams which show cross-sectional views of an active matrix substrate during the substrate production processes of the present invention.

Figures 3: Diagrams which show plane views of the method for irradiating an annealing laser on the peripheral drive circuit region above the active matrix substrate of the present invention.

Explanation of notations

(1): Glass substrate; (2): Active matrix circuit; (3): Peripheral drive circuit; (4): Polycrystalline silicon film; (5): CVD-SiO₂ film; (6): Polycrystalline silicon film; (7): CVD SiO₂ film; (8): Electrode.

【発明の効果】上述の如く本発明は、一対のガラス基板内に電気光学的応答をする組成物が封入されてなり、該ガラス基板にはマトリクス状に配列されたデータ線とゲート線、該データ線と該ゲート線の各交点にはシリコン薄膜トランジスタからなるスイッチング素子及び駆動電極が配置されてアクティブマトリクス回路部を形成してなる電気光学的表示装置において、該アクティブマトリクス回路部外周の該ガラス基板には該データ線及び該ゲート線に信号を提供する周辺駆動回路が形成され、該周辺駆動回路中の能動素子はシリコン薄膜トランジスタで構成されてなり、該周辺駆動回路のシリコン薄膜トランジスタの移動度と該アクティブマトリクス回路部のシリコン薄膜トランジスタの移動度とを異ならせるようにしたからレーザーアニール処理等によって、シリコントランジスタの薄膜の組成変化により容易に移動度の異なる領域を形成することが可能であるために、周辺駆動回路の応答速度は移動度を高くすることによって高周波応答を保證することができ、一方アクティブマトリクス回路部の移動度は低くすることによって、表示領域に入射される光によるトランジスタのオフ時のリーク電流を

最小限に押えることができる。このように移動度に対し両者が互いに背反する特性を有する薄膜トランジスタを同一基板上に構成することが可能である効果を有する。

【図面の簡単な説明】

【図1】 本発明によるアクティブマトリクス基板における回路配置図。

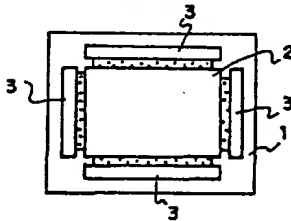
【図2】 (a) から (c) は本発明におけるアクティブマトリクス基板の製造工程を示す基板断面図。

【図3】 (a) から (d) は本発明におけるアクティブマトリクス基板の周辺駆動回路領域へのレーザーアニール照射方法を示す平面図。

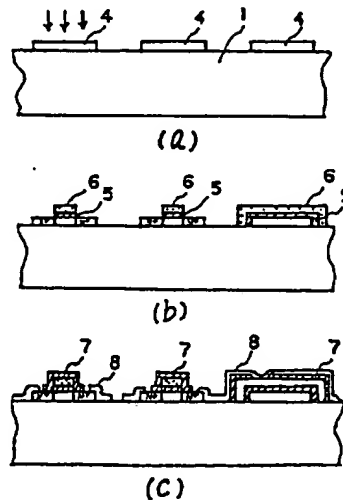
【符号の説明】

- 1・・・ガラス基板
- 2・・・アクティブマトリクス基板
- 3・・・周辺駆動回路
- 4・・・多結晶シリコン膜
- 5・・・CVD-SiO₂膜
- 6・・・多結晶シリコン膜
- 7・・・CVD-SiO₂膜
- 8・・・電極

【図1】



【図2】



【図3】

